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DE-A-1 515 166
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Description

The present invention relates to spark deposition apparatus for coating a surface of a conductive workpiece with a layer of a metallic substance.

In spark-depositing techniques, an electrode typically serves as a source of the substance to be deposited on the workpiece surface. As a localized portion of the electrode and a localized portion of the workpiece surface are brought into and/or out of mutual contact, spark discharge is caused to develop between them with a brief electrical impulse which is of an intensity sufficient to produce fusion of the localized electrode portion so that the localized fusion substance is a small amount is transferred to the small localized discharge-impinging area of the workpiece and cooled thereon to form a firm metallurgical bond with the workpiece substrate. By continuous sweeping such contact discharge over a selected surface region of the workpiece, a uniform layer of the deposit substance which is effective to harden or otherwise modify the original surface can be obtained.

In a typical form of spark-deposition, the electrode may be a solid rotary member rotated to bring its end face in sliding or tangential movement over the workpiece surface and the electrode substance is transferred onto the latter with the aid of repeated contact discharges. Such intermittent contact discharges can be effected by a capacitor circuit designed to charge and instantaneously discharge across the points of contact between the electrode and the workpiece and recharge as the contact regions shift from one contact to a next contact point between the electrode and the workpiece. Otherwise, a mechanical or electrical switching of a continuous voltage source has been employed to provide periodically a pulsed voltage across the moving interface of the electrode and the workpiece.

US patent specification No. 3 741 426 discloses an electrode member composed of the depositable substance may also be repeatedly driven into contact with a workpiece, for example, under a spring force applied to the electrode held resiliently upon an electrode holder. A spark discharge is drawn between the electrode tip and the workpiece from a charged capacitor, thereby creating a partial weld between them. Coupled with the electrode holder, there is an electromagnetic coil designed to be energized at least in part by the charging current of the capacitor or short-circuit condition between the electrode and the workpiece. The coil is thus operable, upon the capacitor discharge, to draw the electrode tip abruptly away from the workpiece surface in order to break the weld and leave substance from the electrode tip deposited upon the workpiece.

With whichever rotary and vibratory systems described is employed, it has so far been commonly believed that spark-depositing operations are relatively laborious and inefficient tasks inasmuch as the operator needs to manipulate the electrode assembly and to renew the consumed electrodes from time to time. Thus, the problems particularly arise where a large workpiece and a number of workpieces should be coated by spark-deposition, necessitating a large amount of the depositable substance to be furnished by the spark-depositing electrodes.

It is an object of the invention to provide an improved spark-deposition apparatus.

According to the present invention there is provided spark deposition apparatus for coating a surface of a conductive workpiece with a layer of a metallic substance, comprising: electrode storage means for storing a plurality of rigid but consumable, unconsumed and elongate electrodes composed of said substances; chuck means supported by a support member and having an inner electrode guide passage having a forward end facing the workpiece surface and a rear open end for receiving successive unconsumed elongate electrodes located in the storage means; clamp means operable to bring the chuck means into a first position in which it will allow an electrode to freely move longitudinally through said passage in the direction of the workpiece and into a second position in which it will clamp the electrode at a given position in the passage so that the electrode projects from the passage with an end face thereof facing the workpiece surface activation means for affecting displacement of the electrode when clamped to cause the end face of the electrode to be in spark-depositing relationship with a local portion of said workpiece surface to transfer an amount of said substance from the electrode to the local portion; power supply for effecting a spark between the electrode and the workpiece when they are in spark-depositing relationship, first drive means for causing relative displacement between said support member and the workpiece surface to effect a spark-deposit of said substance along a programmed path over the workpiece surface, second drive means for causing relative displacement between said support member and the workpiece surface in the direction of the electrode and so allow longitudinal axis of the electrode to compensate for the progressive consumption of the intermittent spark-depositing relationship between the electrode and the workpiece surface to be maintained, command means for generating a command signal when the consumption of the electrode has exceeded a predetermined value to interrupt the operations of said activation means and said first and second drive means; and control means responsive to said command signal to bring said chuck means into said first operating position so as to allow the consumed electrode to escape from said passage and one unconsumed electrode in the storage means to be introduced into said passage and thereafter to bring said chuck means into said second operating position to clamp the newly introduced electrode at a said given position in said passage.

According to the present invention there is further provided spark-deposition apparatus for

coating a surface of a conductive workpiece with a layer of a metallic substance, comprising: chuck means supported by a support member and having an inner electrode guide passage having a forward open end facing the workpiece surface and a rear open end for receiving successive unconsumed elongate electrodes each composed of said substance; clamp means operable to bring the chuck means into a first position in which it will allow an electrode to freely move longitudinally through said passage in the direction of the workpiece surface and into a second position in which it will clamp the electrode at a given position in the passage so that the electrode projects from the passage with an end face thereof facing the workpiece, activation means for effecting displacement of said electrode when clamped to bring the end face of the electrode into a spark-depositing relationship with a local portion of said workpiece surface to cause an amount of said substance to be transferred from the electrode to the local portion; power supply for effecting a spark between the electrode and the workpiece when they are in spark-depositing relationship; first drive means for causing relative displacement between the support member and the workpiece surface to effect a spark-deposit of said substance along a programmed path over the workpiece surface; second drive means for causing relative displacement between said support member and the workpiece surface in the direction of the longitudinal axis of the clamped electrode to compensate for the progressive consumption of the electrode and so allow the intermittent spark-depositing relationship between the electrode and the workpiece to be maintained; command means for generating a command signal when the distance between the support member and the workpiece surface has reached a predetermined minimum, the generation of the command signal acting to interrupt the operations of said activating means and said first and second drive means and control means responsive to said command signal to bring said chuck means into said first operating position so as to allow the electrode therein to move freely along said guide passage, said control means then acting to cause the second drive means to effect relative displacement of said support member away from the workpiece by predetermined distance while maintaining the end face of the electrode in said passage adjacent the workpiece and thereafter to bring said chuck means into said second operating position to clamp the electrode.

Spark-deposition apparatus embodying the present invention will now be described by way of example with reference to the accompanying, diagrammatic drawings in which:

Fig. 1 is a diagrammatic view illustrating an automatic spark-depositing apparatus or machine embodying the present invention;

Fig. 2 is a diagrammatic sectional view illustrating an electrode storage and an electrode support as generally shown in Fig. 1, including a chuck member and clamp means, according to the invention.

Fig. 3 is a perspective view illustrating a chuck and clamp assembly of Fig. 2.

Fig. 4 is a diagrammatic sectional view illustrating another embodiment of the chuck and clamp assembly which may be employed in the apparatus according to the invention.

Fig. 5 is a diagrammatic sectional view illustrating a modified electrode assembly of rotary type which may form a part of the apparatus according to the invention; and

Fig. 6(b) and 6(c) are cross-sectional views illustrating typical forms of the spark-depositing electrode which may be employed in the practice of the present invention.

Referring now to Fig. 1, a rod-form electrode 1 composed of tungsten-carbide or other depositable substance is shown as supported by a support member 2 which is in turn carried on an L-shaped spring plate 3 secured to a block 4. Disposed below the vertical electrode 1 is a conductive workpiece 5 composed of, say, a steel and securely mounted on a cross-table 6 which are movably mounted on a machine bed 7. The machine has a column 8 standing upright on the bed 7 and having a head portion 9 overlying the block 4. A vertical guide post 10 having the bored block 4 slidably fitted thereon extends between the head portion 9 and the bed 7 in parallel to the column 8. The block 4 has a threaded spindle or lead-screw 11 secured thereto so as to be carried thereby. The spindle 11 is in mesh with a nut 12 having a worm wheel 13 secured thereon in a cavity 14 formed in the head portion. The worm wheel 13 is in mesh with a worm 15 secured to the output shaft of a motor 16. Thus when the motor 16 is driven in one direction or another, the block 4 is vertically moved down or up to bring the electrode 1 towards or away from the workpiece 5.

A spark-deposition power supply includes a capacitor 16 chargeable by a DC source 17 and dischargeable across a spark-depositing interface formed between the electrode 1 and the workpiece 5. The DC source 17 is connected to make the workpiece 5 negative and the electrode 1 positive. In the illustrated arrangement, one terminal of the capacitor 16 is connected to the junction between the workpiece 3 and the negative terminal of the DC source 17 while the positive terminal of the DC source 17 is connected to the junction of the other terminal of the capacitor 16 and the electrode 1 via coils 18 of an electromagnet 19 installed in the block 4 in operative juxtaposition with the spring plate 3. As the charging current passes from the DC source 17 to the capacitor 16, the electromagnet 19 is thus energized to magnetically attract the spring plate 5 and thereby to retract the electrode 1 away from the workpiece 5. As the charging current ceases, the electric restitution force of the deformed spring 3 brings the electrode tip into hammering contact with the workpiece surface. As the tip approaches the surface, the charge

stored on the capacitor 16 is discharged through the narrowing interface 18, thus producing an impulsive spark discharge between the electrode 1 and the workpiece 5, which is of sufficient intensity to fuse and transfer a localized amount of the substance of the electrode onto a localized discharge-impinging area of the workpiece 5. As the spark-depositing cycle is thus periodically effected, the workpiece 5 is displaced relative to the electrode 1 so that the electrode tip effectively sweeps over the workpiece surface.

The cross-table 6 carrying the workpiece 5 is thus displaced by means of a pair of motors 20 and 21 in a horizontal or X—Y plane. The motors 20 and 21 are driven by X-axis drive commands and Y-axis drive commands furnished by their respective drive circuits 22 and 23 in response to a sequence of control instructions generated in a program controller 24 to enable the localized spark-deposit of the substance to continue to develop along a programmed path over the workpiece surface. As the spark-deposition continues, the electrode is consumed from the end face to gradually reduce its length. To compensate, for the reduction in the electrode length, a drive control circuit 25 is provided to controlledly rotate the motor 16 and hence to controlledly move the block 4 and in turn the electrode support 2 axially downwards. The control circuit 25 may operate to move the electrode support 2 axially downwards at a predetermined rate in response to a programmed control signal from controller 24, the rate being programmed to compensate for the electrode consumptive reduction based upon empirical data. Alternatively, the reduction compensatory movement of the electrode support 2 can be achieved through a feedback approach. To this end, in the illustrated embodiment, a sensing resistor 26 is connected across the spark-depositing gap in parallel with the capacitor 16 to sense an average gap voltage which is representative of the average distance between the electrode 1 and the workpiece 5. The sensed voltage can be compared with a reference voltage in the control circuit 25 to produce a correction signal which is applied to the motor 16 to advance the electrode support 2 until the voltage signal being sensed becomes equal to the reference voltage. By so controlledly advancing the electrode support 2 downwards, it is possible to maintain the intermittent spark-depositing relationship of the electrode tip with the workpiece surface in spite of the gradual consumptive reduction of the electrode length.

The machine shown also includes a housing 27 which stores a plurality of unconsumed rod electrodes and is carried on the block 4 above the electrode support 2. The electrode housing 27 is connected to the block 4 so as to be vertically movable up and down by means of a drive unit 28 which is driven by a control signal furnished from the controller 24. As shown in Fig. 2, the housing 27 has a plurality of unconsumed rod electrodes 1*a* stored therein and has a cylindrical body portion 27*a* slidably receivable towards its lower, downwardly converging open end portion 27*b* with a top-open cylindrical receptacle 2*a* constituting the electrode support member 2. The cylindrical body portion 27*a* is closed by a cap-shaped cover 27*c* which is threaded thereto. The cylindrical receptable 2*a* centrally accommodates a chuck member 29 and has a centrally bored end wall 2*b* arranged to retain the member 29. The chuck member 29 internally defines an elongate electrode passage 30 having its lower end 30*a* open towards the workpiece 5 and its upper open end 30*b* adapted to adjoin smoothly with the lower open end 27*b* of the housing 27 when the latter enters slidingly into the receptacle 2*a*. In the embodiment illustrated, the electrodes 1*a* (1) are cylindrical rods of an equal length and an equal diameter, and the electrode guidance passage 30 is circular in cross-section and, throughout its length, has a diameter slightly greater than the rod diameter. As seen from Fig. 3, the hollow member 29 has its lower portions which increases downwardly in wall thickness and in which a plurality of longitudinal slits 29*b* are formed symmetrically about the axis of the member 29.

In the embodiment of Figs. 2 and 3, a like plurality of segments 31 are disposed to surround the lower portion 29*a* and serve to constitute a clamp means for the chuck member 29. Thus, in the embodiment illustrated, there segments 31 are resiliently supported by springs 31*a* to maintain their horizontal positions. The segments 31 are ferromagnetic and a solenoid 32 is wound around the cylindrical receptacle 2*a* as energizable by a control circuit 33. Thus, when the solenoid 32 is energized by the control circuit 33, the ferromagnetic segments 31 are electromagnetically attracted together to compress the slitted lower portion 29*a* of the hollow member 29 inwardly. When the solenoid 33 is deenergized, the segments 31 tend to repel each other against the spring pressure, thus permitting the slitted lower portion 29*a* of the hollow member 29 to expand outwardly. The control circuit 33 operates in response to command signals from the controller 24.

In the embodiment shown in Fig. 4, the hollow chuck member 29 is formed with an outer threaded surface 29c on which a nut 34 is fitted to mesh therewith. The nut 34 has a geared periphery in mesh with a toothed rod 35 which has at its top a gear 36 in mesh with a gear 37 secured to the output shaft of a motor 38, which is rotatable by a control circuit 39. Thus, when the motor 38 is rotated in one direction, the geared nut 34 is moved downwards to compress the slitted lower end 29*a* of the hollow member 29 inwardly. When the motor 38 is rotated in the other direction, the nut 34 is moved upwards to allow the slitted lower end 29*a* of the hollow member 29 to expand outwards. Here again, the control circuit 39 operates in response to command signals from the controller 24.

Each of the clamp means 31 of Figs. 2 and 3 and the clamp means 34 of Fig. 4 is thus adapted to bring the chuck member 29 in a first operating

position to allow the electrode 1 to freely move longitudinally through the guide passage 30 in the direction of the workpiece 5 in the chuck member 29. With the support member 2 spaced by a given initial distance from the workpiece 5, the electrode 1 is allowed to move towards the workpiece 5, here downwards by gravity, until it comes into contact with the workpiece 5. Then, the clamp means 34 is activated to bring the chuck member 29 in a second operating position to hold the electrode 1 fast at that position in the passage 30. At this stage the electrode 1 lies partly projecting from the passage 30 by the initial distance of the support member 2 from the workpiece 5.

During the spark-depositing operation, the motor 16 (Fig. 1) acts to advance the support member 2 towards the workpiece 5 so as to maintain the spark-depositing relationship of the electrode tip or end face with the workpiece surface and to compensate for the reduction of the electrode length. The programmed controller 24 is adapted to generate a command signal representing a predetermined distance of approach of the support member 2 to the workpiece 5, the command signal being transmitted to the motors 16, 20, 21 to interrupt the operations thereof, to the power supply 17 to interrupt the spark discharges and the electrode vibrations, and to the control circuit 33, 39 to act on the clamp means 31, 34 to bring the chuck member 29 first into the first operating position to set free the electrode 1 in the passage 30. The control command is applied to the motor 16 to move the support member 2 upwards by a distance which can be equal to the above-mentioned predetermined distance of approach while leaving the electrode 1 with its tip in contact with the workpiece 5. Then, the control circuit 33, 39 acts on the clamp means 31, 34 to bring the chuck member 29 into the second operating position to hold the electrode 1 fast at that position in the passage 30. Then, the motors 16, 20, 21 are allowed to resume their operations and the power supply 17 is again turned on to resume the spark discharges and the electrode vibrations. A sequence of such command signals are generated from the controller 24 to repeat the retraction of the support member 2. This causes the length of the electrode 1 within the passage 30 to be stepwise reduced.

The controller 24 provides another command signal representing the reduction of the electrode length in excess of a predetermined value, the control command being transmitted to the motors 16, 20, 21 to interrupt their operations, to the power supply 17 to interrupt the spark discharges and the electrode vibrations, and to the control circuit 33, 39 to act on the clamp means 31, 34, to bring the chuck member 29 first into the first operating position to allow the shortened electrode to drop by gravity onto the workpiece 5. A fluid jet device 40 which can be disposed in the vicinity of the working zone may be actuated to apply a blast of air or gas in the working zone under a pressure sufficient to carry away the dropped electrode for disposal. The control command is applied to the motor 28 to move the housing 27 into its electrode transfer position such that one of the stored electrodes 1*a* may be introduced into the electrode guide passage 30, as indicated by broken lines in Figs. 2 and 4. The introduced unconsumed electrode 1*a* is allowed to move downwards by gravity through the passage until its tip comes into contact with the workpiece 5, whereupon the operation as aforesaid is resumed.

Fig. 5 shows a modified electrode support assembly 2' which, instead of being vibratorily coupled to the block 4 as previously described, is secured to the block 4 in the arrangement of Fig. 1. In this assembly, the cylindrical receptacle 2*a* has a geared collar 41 secured thereto which is mesh with a gear 42 secured to the output shaft of a motor 43. The receptacle 2*a* has a chuck member 29 and clamp means 31, 31*a* mounted therein which operate as previously described in connection with Figs. 2 and 3. In this modified assembly, however, the energizing solenoid 33 is secured to the inner wall of a housing 44 which is provided to accommodate the gear 42 and the collared support member 2*a* therein. The motor 43 can be mounted on a top portion of the housing 44 and is driven to rotate the electrode support 2*a* and thus the electrode 1 about a longitudinal axis of the electrode support 2*a* while the electrode 1 is held in contact with the workpiece surface, thereby providing a rapid rotary or cyclic sliding motion of the electrode end face therewith. A spark-depositing power supply 17' has a positive terminal electrically connected to the electrode 1 via a brush 45, a conductive ring 46 and the conductive chuck member 29 and a negative terminal electrically connected to the workpiece 5 to apply a succession of electrical pulses between the workpiece 5 and the end face of the electrode moving in sliding contact therewith. Intermittent spark discharges thus develop between localized contact areas of the electrode end face and the workpiece surface to intermittently transfer the electrode substance onto the workpiece discharge areas. The elongate cylindrical electrode 1 (1a) typically is a solid cylinder as shown in cross-section in Fig. 6(a). A tubular or hollow cylindrical form of the electrode which is annular or C-shaped in cross section as shown in Figs. 6(b) and 6(c) is often advantageously employed. With the rotary system described, it is also found advantageous to make the axis of the electrode 1 eccentric with the axis of rotation so that the electrode end face cover a larger area over the workpiece surface in each rotary cycle.

Claims

1. Spark deposition apparatus for coating a surface of a conductive workpiece (5) with a layer of metallic substance, comprising:

electrode storage means (27) for storing a plurality of rigid but consumable, unconsumed and elongate electrodes (1a) composed of said substance;

chuck means (29) supported by a support

member (2) and having an inner electrode guide passage having a forward open end facing the workpiece surface and a rear open end for receiving successive unconsumed elongate electrodes (1a) located in the storage means (27);

clamp means (31) operable to bring the chuck means (2a) into a first position in which it will allow an electrode (1) to freely move longitudinally through said passage in the direction of the workpiece and into a second position in which it will clamp the electrode (1) at a given position in the passage so that the electrode (1) projects from the passage with an end face thereof facing the workpiece surface (5);

activation means (18, 43) for effecting displacement of the electrode (1) when clamped to cause the end face of the electrode (1) to be in spark-depositing relationship with a local portion of said workpiece surface (5) to transfer an amount of said substance from the electrode to the workpiece surface local portion;

power supply (17) for effecting a spark between the electrode and the workpiece when they are in spark-depositing relationship;

first drive means (22, 23) for causing relative displacement between said support member (2) and the workpiece surface (5) to effect a spark-deposit of said substance along a programmed path over the workpiece surface;

second drive means (28) for causing relative displacement between said support member (2) and the workpiece surface (5) in the direction of the electrode and so allow longitudinal axis of the electrode to compensate for the progressive consumption of the intermittent spark-depositing relationship between the electrode (1) and the workpiece surface (5) to be maintained;

command means (24) for generating a command signal when the consumption of the electrode has exceeded a predetermined value to interrupt the operations of said activation means and said first and second drive means; and

control means (33) responsive to said command signal to bring said chuck means (29) into said first operating position so as to allow the consumed electrode (1) to escape from said passage and one unconsumed electrode (1a) in the storage means (27) to be introduced into said passage and thereafter to bring said chuck means (29) into said second operating position to clamp the newly introduced electrode (1a) at a said given position in said passage.

2. Apparatus according to Claim 1 wherein said command means (24) is arranged to generate a second command signal when the distance between the support member (2) and the workpiece surface has reached a predetermined minimum, the operation of the second command signal acting to interrupt the operations of the activating means (18, 43) and said first and second drive means, and then acting on the control means (33) to bring the chuck means (29) into said first position to allow the electrode (1) to move along said guide passage, the second command signal then acting on said second drive means (28) to cause the support member (2) and the workpiece surface (5) to become spaced from one another by a predetermined distance while maintaining the end face of the electrode (1) adjacent the workpiece (5) and thereafter acting on said control means (33) to bring the chuck means (29) into said second position to clamp the electrode (1) in said passage.

3. Apparatus according to Claim 2 wherein the command means (24) is arranged to generate a sequence of second command signals for acting as aforementioned before the electrode has been consumed by said predetermined amount.

4. Apparatus according to any preceding claim wherein said activating means (18, 43) includes means (18) for vibrating said support member (2) to cause the electrode and the workpiece to intermittently make and break contact, the workpiece (5) and the electrode (1) being in spark-depositing relationship when they make contact.

5. Apparatus according to any preceding claim wherein said activating means (18, 43) includes means (43) for rotating said support member (2) about an axis thereof so as to cyclically move the end face of the electrode (1) in sliding contact with the workpiece surface, wherein the means (17) for effecting a spark produces sparks intermittently.

6. Spark-deposition apparatus for coating a surface of a conductive workpiece (5) with a layer of a metallic substance, comprising:

chuck means (29) supported by a support member (2) and having an inner electrode guide passage having a forward open end facing the workpiece surface and a rear open end for receiving successive unconsumed elongate electrodes (19) each composed of said substance;

clamp means (31) operable to bring the chuck means (29) into a first position in which it will allow an electrode (1) to freely move longitudinally through said passage in the direction of the workpiece surface (5) and into a second position in which it will clamp the electrode (1) at a given position in the passage so that the electrode (1) projects from the passage with an end face thereof facing the workpiece surface (5);

activation means (18, 43) for effecting displacement of said electrode (1) when clamped to bring the end face of the electrode into a spark-depositing relationship with a local portion of said workpiece surface to cause an amount of said substance to be transferred from the electrode (1) to the local portion;

power supply (17) for effecting a spark between the electrode and the workpiece when they are in spark-depositing relationship;

first drive means (22, 23) for causing relative displacement between the support member (2) and the workpiece surface (5) to effect a spark-deposit of said substance along a programmed path over the workpiece surface;

second drive means (28) for causing relative displacement between said support member (2) and the workpiece surface (5) in the direction of the longitudinal axis of the clamped electrode (1) to compensate for the progressive consumption

of the electrode (1) and so allow the intermittent spark-depositing relationship between the electrode (1) and the workpiece (5) to be maintained;

command means (24) for generating a command signal when the distance between the support member (2) and the workpiece surface has reached a predetermined minimum, the generation of the command signal acting to interrupt the operations of said activating means and said first and second drive means (22, 23, 28) and

control means responsive to said command signal to bring said chuck means (29) into said first operating position so as to allow the electrode (1) therein to move freely along said guide passage, said control means then acting to cause the second drive means (28) to effect relative displacement of said support member (2) away from the workpiece (5) by predetermined distance while maintaining the end face of the electrode (1) in said passage adjacent the workpiece (5) and thereafter to bring said chuck means (29) into said second operating position to clamp the electrode (1).

7. Apparatus according to Claim 6 wherein said command means (24) is also arranged to generate a command signal when the consumption of clamped electrode (1) has exceeded a predetermined amount.

8. Apparatus according to Claim 7 wherein said command means (24) is arranged to generate a second command signal when the consumption of the clamped electrode (1) has exceeded a predetermined amount, the production of the second command signal interrupting the operations of said activating means (18, 43) and said first and second drive means (22, 23, 28) and causing the control means (33) to bring said chuck means (29) into the first position to allow the consumed electrode (1) to escape from said passage, the apparatus further comprising:

an electrode storage means (27) for storing a plurality of unconsumed electrodes (1a); and

means operable in response to said second command signal for transferring one of said unconsumed electrodes (1a) in said storage means (27) into said passage and then causing said control means (33) to bring the chuck means (29) into the second position to clamp the newly introduced electrode (1a) at a given position in said passage.

9. Apparatus according to any one of Claims 6 to 8 wherein said activating means (18, 43) comprises vibrating means (18) for vibrating the support member (2) to cause the electrode (1) and the workpiece (5) to intermittently make and break contact, the electrode (1) and the workpiece (5) being in spark-depositing relationship when they make contact.

10. Apparatus according to any one of Claims 6 to 8 wherein said activating means (18, 43) includes means (43) for rotating said support member (2) about an axis thereof so as to cyclically move the said electrode (1) in sliding contact with the workpiece (5) and wherein the means (17) for producing a spark produces sparks intermittently.

Patentansprüche

1. Funkenbelegungsapparat zum Beschichten einer Oberfläche eines leitenden Werkstücks (5) mit einer Schicht eines metallischen Materials, umfassend:

eine Elektrodenvorratseinheit (27), in der eine Mehrzahl unbiegsame, jedoch verbrauchbare, unverbrauchte und langgesterckte Elektroden (1a) aus diesem Material aufgenommen ist;

eine Einspannvorrichtung (29), die an einer Halterung (2) gehaltert ist und einen inneren Elektrodenführungsdurchgang mit einem der Werkstückoberfläche zugewandten offenen Vorderende und einem offenen Hinterende zur Aufnahme aufeinanderfolgender unverbrauchter Mengen langgestreckter Elektroden (1a), die in der Vorratseinheit (27) angeordnet sind, aufweist;

eine Klemmvorrichtung (31), die die Einspannvorrichtung (29) in eine erste Stellung bringt, in der sich eine Elektrode (1) ungehindert in Längsrichtung durch den Druchgang in Richtung des Werkstücks bewegen kann, und in eine zweite Stellung bringt, in der sie die Elektrode (1) an einer bestimmten Position im Durchgang festklemmt, so daß die Elektrode (1) aus dem Durchgang ragt, wobei ihre Endfläche der Werkstückoberfläche gegenübersteht;

eine Betätigungsvorrichtung (18, 43), die eine Verschiebung der festgeklemmten Elektrode (1) bewirkt, so daß die Endfläche der Elektrode (1) in eine Funkenbelegungs-Beziehung mit einem örtlichen Abschnitt der Werkstückoberfläche (5) gelangt zur Übertragung einer Materialmenge von der Elektrode auf den örtlichen Abschnitt der Werkstückoberfläche;

eine Stromversorgung (17), die zwischen der Elektrode und dem Werkstück einen Funken erzeugt, wenn sich diese in Funkenbelegungs-Beziehung befinden;

einen ersten Antrieb (22, 23), der eine relative Verschiebung zwischen der Halterung (2) und der Werkstückoberfläche (5) bewirkt, so daß eine Funkenbelegung mit dem genannten Material entlang einer programmierten Bahn über die Werkstückoberfläche stattfindet;

einen zweiten Antrieb (28), der eine relative Verschiebung zwischen der Halterung (2) und der Werkstückoberfläche (5) in Richtung der Längsachse der Elektrode bewirkt, so daß der fortschreitende Verbrauch der Elektrode ausgeglichen und so die intermittierende Funkenbelegungs-Beziehung zwischen der Elektrode (1) und der Werkstückoberfläche (5) unterhalten werden kann;

eine Regeleinheit (24), die ein Regelsignal erzeugt, wenn der Elektrodenverbrauch einen vorgegebenen Wert überschreitet, so daß der Betrieb der Betätigungsvorrichtung und des ersten und zweiten Antriebs unterbrochen wird;

eine Steuereinheit (33), die aufgrund des Regelsignals die Einspannvorrichtung (29) in die erste

Betriebsstellung bringt, so das die verbrauchte Elektrode aus dem Durchgang entfernbar und eine unverbrauchte Elektrode (1a) aus der Vorratseinheit (27) in diesen Durchgang einführbar ist, und anschließend die Einspannvorrichtung (20) in die zweite Betriebsstellung bringt unter Festklemmen der neu eingeführten Elektrode (1a) an der gegebenen Position in dem Durchgang.

2. Apparat nach Anspruch 1, wobei die Regeleinheit (24) ein zweites Regelsignal erzeugt, wenn die Entfernung zwischen der Halterung (2) und der Werkstückoberfläche einen vorbestimmten Minimalwert erreicht, wobei das zweite Regelsignal den Betrieb der Betätigungsvorrichtung (18, 43) und des ersten und zweiten Antriebs unterbricht, und dann die Steuereinheit (33) beaufschlagt, um die Einspannvorrichtung (29) in die erste Stellung zu bringen, so daß die Elektrode (1) entlang dem Führungsdurchgang bewegbar ist, wobei das zweite Regelsignal dann den zweiten Antrieb (28) beaufschlagt, so daß die Halterung (2) und die Werkstückoberfläche (5) um einen vorgegebenen Betrag voneinander beabstandet werden, während die Endfläche der Elektrode (1) angrenzend an das Werkstück (5) gehalten wird, und danach die Steuereinheit (33) beaufschlagt, so daß die Einspannvorrichtung (29) in die zweite Stellung gebracht wird und die Elektrode (1) in dem Durchgang festklemmt.

3. Apparat nach Anspruch 2, wobei die Regeleinheit (24) eine Folge zweiter Regelsignale erzeugt, die in der vorgenannten Weise wirksam werden, bevor die Elektrode um den vorgegebenen Betrag verbraucht ist.

4. Apparat nach einem der vorhergehenden Ansprüche, wobei die Betätigungsvorrichtung (18, 43) Mittel (18) zur Vibration der Halterung (2) aufweist, so daß die Elektrode und das Werkstück intermittierend einander kontaktieren bzw. voneinander getrennt werden, wobei das Werkstück (5) und die Elektrode (1) bei der Kontaktierung eine Funkenbelegungs-Beziehung haben.

5. Apparat nach einem der vorhergehenden Ansprüche, wobei die Betätigungsvorrichtung (18, 43) Mittel (43) zum Drehen der Halterung (2) um eine Achse derselben aufweist, so daß die Endfläche der Elektrode (1) zyklisch in Gleitkontakt mit der Werkstückoberfläche bewegbar ist, wobei der Mittel (17) zur Funkenbildung Intermittierend Funken erzeugen.

6. Funkenbelegungsapparat zum Beschichten einer Oberfläche eines leitenden Werkstücks (5) mit einer Schicht eines metallischen Materials, umfassend:

eine Einspannvorrichtung (29), die an einer Halterung (2) gehaltert ist und einen inneren Elektrodenführungsdurchgang mit einem der Werkstückoberfläche zugewandten offenen Vorderende und einem offenen Hinterende zur Aufnahme aufeinanderfolgender unverbrauchter Mengen langgestreckter Elektroden (19), die jeweils aus diesen Material bestehen, aufweist;

eine Klemmvorrichtung (31), die die Einspannvorrichtung (29) in eine erste Stellung bringt, in der sich eine Elektrode (1) ungehindert in Längsrichtung durch den Durchgang in Richtung des Werkstücks bewegen kann, und in eine zweite Stellung bringt, in der sie die Elektrode (1) an einer bestimmten Position im Durchgang festklemmt, so daß die Elektrode (1) aus dem Durchgang ragt, wobei ihre Endfläche der Werkstückoberfläche (5) gegenübersteht;

eine Betätigungsvorrichtung (18, 43), die eine Verschiebung der festgeklemmten Elektrode (1) bewirkt, so daß die Endfläche der Elektrode (1) in eine Funkenbelegungs-Beziehung mit einem örtlichen Abschnitt der Werkstückoberfläche (5) gebracht wird zur Übertragung einer Materialmenge von der Elektrode auf den örtlichen Abschnitt;

eine Stromversorgung (17), die zwischen der Elektrode und dem Werkstück einen Funken erzeugt, wenn sich diese in Funkenbelegungs-Beziehung befinden;

einen ersten Antrieb (22, 23), der eine relative Verschiebung zwischen der Halterung (2) und der Werkstückoberfläche (5) bewirkt, so daß eine Funkenbelegung mit dem genannten Material entlang einer programmierten Bahn über die Werkstückoberfläche stattfindet;

einen zweiten Antrieb (28), der eine relative Verschiebung zwischen der Halterung (2) und der Werkstückoberfläche (5) in Richtung der Längsachse der festgeklemmten Elektrode bewirkt, so daß der fortschreitende Verbrauch der Elektrode ausgeglichen und so die intermittierende Funkenbelegungs-Beziehung zwischen der Elektrode (1) und der Werkstückoberfläche (5) unterhalten werden kann;

eine Regeleinheit (24), die ein Regelsignal erzeugt, wenn der Abstand zwischen der Halterung (2) und der Werkstückoberfläche einen vorbestimmten Mindestwert erreicht, wobei die Erzeugung des Regelsignals den Betrieb der Betätigungsvorrichtung und des ersten und zweiten Antriebs (22, 23, 28) unterbricht; und eine Steuereinheit, die aufgrund des Regelsignals die Einspannvorrichtung (29) in die erste Betriebsstellung bringt, so daß die darin befindliche Elektrode (1) ungehindert entlang dem Führungsdurchgang bewegbar ist, wobei die Steuereinheit dann den zweiten Antrieb (28) beaufschlagt, um eine relative Verschiebung der Halterung (2) weg vom Werkstück (5) um einen vorgegebenen Betrag zu bewirken, während die Endfläche der Elektrode (1) in dem Durchgang angrenzend an das Werkstück (5) gehalten wird, und danach die Einspannvorrichtung (29) in die zweite Betriebsstellung zum Festspannen der Elektrode (1) bringt.

7. Apparat nach Anspruch 6, wobei die Regeleinheit (24) auch ein Regelsignal erzeugt, wenn der Verbrauch der festgespannten Elektrode (1) ein vorbestimmtes Maß überschreitet.

8. Apparat nach Anspruch 7, wobei die Regeleinheit (24) ein zweites Regelsignal erzeugt, wenn der Verbrauch der festgespannten Elektrode (1) ein vorbestimmtes Maß übersteigt, und die Erzeugung des zweiten Regelsignals den Betrieb der Betätigungsvorrichtung (18, 43) und des ersten und zweiten Antriebs (22, 23, 28)

unterbricht und die Steuereinheit (33) veranlaßt, die Einspannvorrichtung (29) in die erste Lage zu bringen, so daß die verbrauchte Elektrode (1) aus dem Durchgang fallen kann, wobei der Apparat ferner umfaßt:

eine Elektrodenvorratseinheit (27), in der eine Mehrzahl unverbrauchte Elektroden (1a) speicherbar ist; und Mittel, die aufgrund des zweiten Regelsignals wirksam werden und eine der unverbrauchten Elektroden (1a) aus der Vorratseinheit (27) in den Durchgang überführen und dann die Steuereinheit (33) veranlassen, die Einspannvorrichtung (29) in die zweite Stellung zu bringen, so daß die neu eingeführte Elektrode (1a) an einer bestimmten Position im Durchgang festgespannt wird.

9. Apparat nach einem der Ansprüche 6—8, wobei die Betätigungsvorrichtung (18, 43) einen Vibrator (18) umfaßt, der die Halterung (2) mit Vibrationen beaufschlagt, so daß die Elektrode (1) und das Werkstück (5) intermittierend einander kontaktieren bzw. voneinander getrennt werden, wobei die Elektrode (1) und das Werkstück (5) bei der Kontaktierung eine Funkenbelegungs-Beziehung haben.

10. Apparat nach einem der Ansprüche 6—8, wobei die Betätigungsvorrichtung (18, 43) Mittel (43) zum Drehen der Halterung (2) um eine Achse derselben aufweisen, so daß die Elektrode (1) zyklisch in Gleitkontakt mit dem Werkstück (5) bewegbar ist, und wobei die Mittel (17) zur Funkenerzeugung intermittierend Funken erzeugen.

Revendications

1. Appareil de dépôt par étincelage pour revêtir une surface d'une pièce conductrice (5) avec une couche d'une substance métallique, comprenant:

un magasin d'électrodes (27) pour stocker une multiplicité d'électrodes non consommées et allongées, rigides mais consommables (1a) constituées par cette substance;

des moyens de mandrin (29) supportée par un support (2) et ayant un passage de guidage d'électrode intérieur avec une extrémité avant ouverte en vis-à-vis de la surface de la pièce et une extrémité arrière ouverte pour recevoir successivement des électrodes allongées non consommées (1a) disposées dans le magasin (27);

un moyen de serrage (31) pouvant être mis en oeuvre pour amener le mandrin (29) dans une première position, dans laquelle il permet à une électrode (1) de se déplacer librement longitudinalement à travers le passage en direction de la pièce et, dans une deuxième position, dans laquelle il bride l'électrode (1) dans une position donnée dans le passage de façon que l'électrode (1) se projette du passage avec sa face terminale en vis-à-vis de la surface de la pièce (5);

des moyens d'actionnement (18, 43) pour déplacer l'électrode (1) lorsqu'elle est bridée pour amener la face terminale de l'électrode (1) en position relative de dépôt par étincelage par rapport à une portion locale de la surface de la pièce (5) et transférer ainsi une certaine quantité de la substance de l'électrode sur la portion locale de la surface de la pièce;

une source de courant (17) pour déclencher une étincelle entre l'électrode et la pièce lorsqu'elles sont dans leur position relative de dépôt par étincelage;

un premier moyen d'entraînement (22, 23) pour provoquer un déplacement relatif entre le support (2) et la surface de la pièce (5) pour effectuer un dépôt par étincelage de la substance selon un trajet programmé sur la surface de la pièce;

un deuxième moyen d'entraînement (28) pour provoquer un déplacement relatif entre le support (22) et la surface de la pièce (5) dans la direction de l'électrode et permettre ainsi à l'axe longitudinal de l'électrode de compenser la consommation progressive de la longueur de l'électrode afin de maintenir la position relative de dépôt par étincelage intermittent entre l'électrode (1) et la surface de la pièce (5);

des moyens d'ordre (24) pour produire un signal d'ordre lorsque la consommation de l'électrode a dépassé une valeur prédéterminée afin d'interrompre les opérations des moyens d'actionnement et du premier moyen et du deuxième moyen d'entraînement; et

des moyens de commande (33) répondant à ce signal d'ordre pour amener le mandrin (29) dans la première position opérationnelle et permettre ainsi à l'électrode consommée (1) de s'évacuer du passage et à une électrode non consommée (1a) dans le magasin (27) d'être introduite dans le passage, et pour amener ensuite le mandrin (29) dans la deuxième position opérationnelle et brider ainsi l'électrode nouvellement introduite (1a) dans une position donnée dans le passage.

2. Appareil selon la revendication 1, dans lequel les moyens d'ordre (24) sont disposés pour produire un deuxième signal d'ordre lorsque la distance entre le support (2) et la surface de la pièce a atteint un minimum prédéterminé, ce deuxième signal d'ordre agissant pour interrompre les opérations des moyens d'actionnement (18, 43) et du premier moyen et du deuxième moyen d'entraînement, et agissant ensuite sur les moyens de commande (33) pour amener le mandrin (29) dans la première position et permettre ainsi à l'électrode (1) de se déplacer le long du passage de guidage, le deuxième signal d'ordre agissant ensuite sur le deuxième moyen d'entraînement (28) pour espacer le support (2) et la surface de la pièce (5) l'un de l'autre d'une distance prédéterminée tout en maintenant la face terminale de l'électrode (1) adjacente à la pièce (5), et agissant ensuite sur les moyens de commande (33) pour amener le mandrin (29) dans la deuxième position pour brider l'électrode (1) dans le passage.

3. Appareil selon la revendication 2, dans lequel les moyens d'ordre (24) sont disposés pour produire une séquence de deuxièmes signaux d'ordre pour agir comme précédemment avant que l'électrode ait été consommée de cette quantité prédéterminée.

4. Appareil selon l'une quelconque des revendi-

cations précédentes, dans lequel les moyens d'actionnement (18, 43) comportent des moyens (18) pour faire vibrer le support (2) et amener, de façon intermittente, la pièce et l'électrode en contact et hors de contact, la pièce (5) et l'électrode (1) étant en position relative de dépôt par étincelage lorsqu'elles sont en contact.

5. Appareil selon l'une quelconque des revendications précédentes, dans lequel les moyens d'actionnement (18, 43) comportent des moyens (43) pour faite tourner le support (2) autour de son axe de façon à déplacer cycliquement la face terminale de l'électrode (1) en contact glissant avec la surface de la pièce, les moyens (17) pour déclencher une étincelle produisant alors par intermittence des étincelles.

6. Appareil de dépôt par étincelage pour revêtir une surface d'une pièce conductrice (5) avec une couche d'une substance métallique, comprenant:

un mandrin (29) supporté par un support (2) et ayant un passage de guidage d'électrode intérieur avec une extrémité avant ouverte en vis-à-vis de la surface de la pièce et une extrémité arrière ouverte pour recevoir successivement des électrodes allongées non consommées (1a) composées chacune de cette substance;

un moyen de serrage (31) pouvant être mis en oeuvre pour amener le mandrin (29) dans une première position dans laquelle il permet à une électrode (1) de se déplacer librement longitudinalement à travers le passage en direction de la surface de la pièce (5) et dans une deuxième position dans laquelle il bride l'électrode (1) dans une position donnée dans le passage, de façon que l'électrode (1) se projette du passage avec sa face terminale en vis-à-vis de la surface de la pièce (5);

des moyens d'actionnement (18, 45) pour provoquer le déplacement de l'électrode (1) lorsqu'elle est bridée pour amener la face terminale de l'électrode en position relative de dépôt par étincelage par rapport à une portion locale de la surface de la pièce et transférer ainsi une certaine quantité de cette substance de l'électrode (1) sur cette portion locale;

une source de courant (17) pour déclencher une étincelle entre l'électrode et la pièce lorsqu'elles sont dans leur position relative de dépôt par étincelage;

un premier moyen d'entraînement (22, 23) pour provoquer un déplacement relatif entre le support (2) et la surface de la pièce (5) et effectuer ainsi un dépôt par étincelage de la substance selon un trajet programmé sur la surface de la pièce;

un deuxième moyen d'entraînement (28) pour provoquer un déplacement relatif entre le support (2) et la surface de la pièce (5) dans la direction de l'axe longitudinal de l'électrode bridée (1) afin de compenser la consommation progressive de l'électrode (1) et permettre ainsi de maintenir la position relative de dépôt par étincelage intermittent entre l'électrode (1) et la pièce (5);

des moyens d'ordre (24) pour produire un signal d'ordre lorsque la distance entre le support (2) et la surface de la pièce a atteint une valeur minimale prédéterminée, la production de ce signal d'ordre agissant pour interrompre les opérations des moyens d'actionnement et du premier et du deuxième moyen d'entraînement (22, 23, 28); et

des moyens de commande répondant à ce signal d'ordre pour amener le mandrin (29) dans la première position opérationnelle et permettre ainsi à l'électrode (1) de se déplacer librement le long du passage de guidage, les moyens de commande agissant ensuite pour amener le deuxième moyen d'entraînement (28) à provoquer un déplacement relatif du support en l'éloignant de la pièce (5) d'une distance prédéterminée tout en maintenant la face terminale de l'électrode (1) dans ce passage adjacente à la pièce (5) et pour amener ensuite le mandrin (29) dans la deuxième position opérationnelle pour brider l'électrode (1).

7. Appareil selon la revendication 6, dans lequel les moyens d'ordre (24) sont également disposés pour produire un signal d'ordre lorsque la consommation de l'électrode bridée (1) a dépassé une valeur prédéterminée.

8. Appareil selon la revendication 7, dans lequel les moyens d'ordre (24) sont disposés pour produire un deuxième signal d'ordre lorsque la consommation de l'électrode bridée (1) a dépassé une valeur prédéterminée, la production du deuxième signal d'ordre interrompant les opération des moyens d'actionnement (18, 45) et du premier moyen et du deuxième moyen d'entraînement (22, 23, 28) et faisant que les moyens de commande (33) amènent le mandrin (29) dans sa première position pour permettre à l'électrode consommée (1) de s'évacuer du passage, l'appareil comportant, en outre;

un magasin d'électrodes (27) pour stocker une multiplicité d'électrodes non consomées (1a); et

des moyens pouvant être mis en oeuvre en réponse au deuxième signal d'ordre pour transférer l'une de ces électrodes non consommées (1a) dans le magasin (27) dans le passage et faire ensuite que les moyens de commande (33) amènent le mandrin (29) dans sa deuxième position pour brider l'électrode nonvellement introduite (1a) dans une position donnée dans le passage.

9. Appareil selon l'une quelconque des revendications 6 à 8, dans lequel les moyens d'actionnement (18, 43) comportent des moyens de vibrations (18) pour faire vibrer le support (2) et amener de façon intermittente l'électrode (1) et la pièce (5) en contact et hors de contact, l'électrode (1) et la pièce (5) étant en position relative de dépôt par étincelage lorsqu'elles sont en contact.

10. Appareil selon l'une quelconque des revendications 6 à 8, dans lequel des moyens d'actionnement (18, 43) comportent des moyens (43) pour faire tourner le support (2) autour de son axe, de façon à déplacer cycliquement l'électrode (1) en contact glissant avec la pièce (5) et dans lequel les moyens (17) pour produire une étincelle produisent des étincelles de façon intermittente.

FIG.1

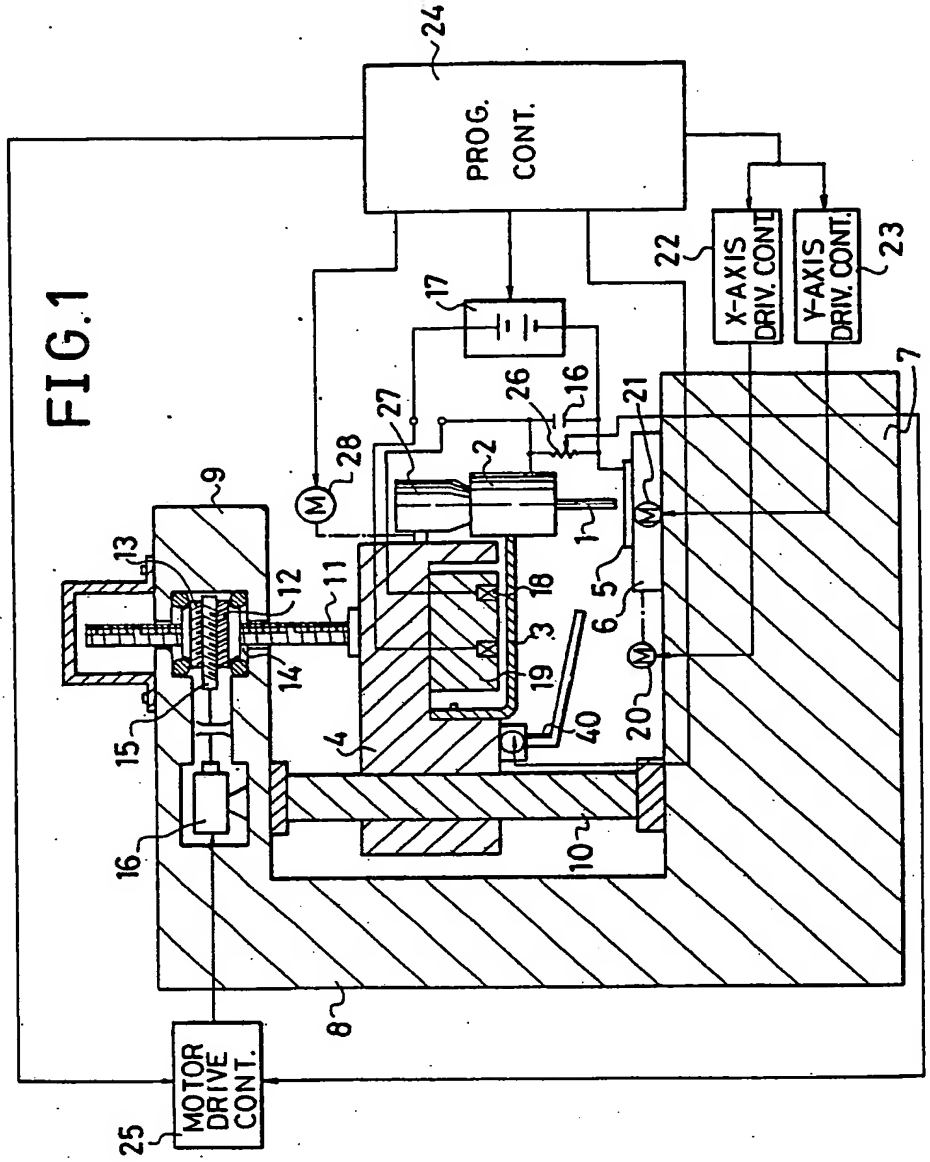

FIG.2

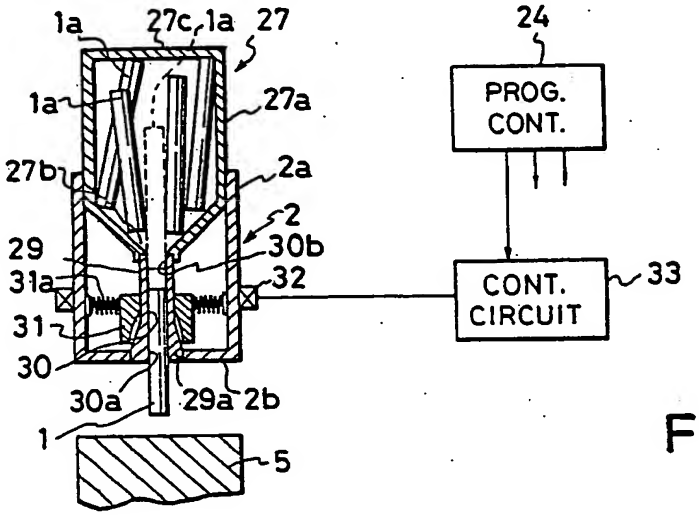

FIG.3

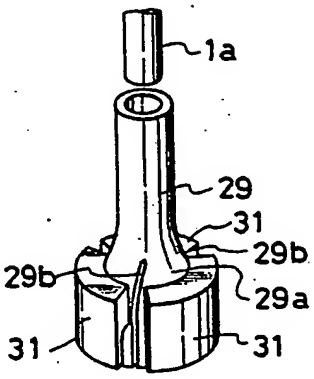

FIG.4

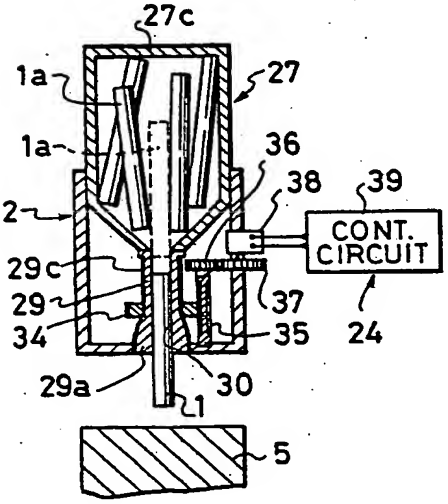

FIG. 5

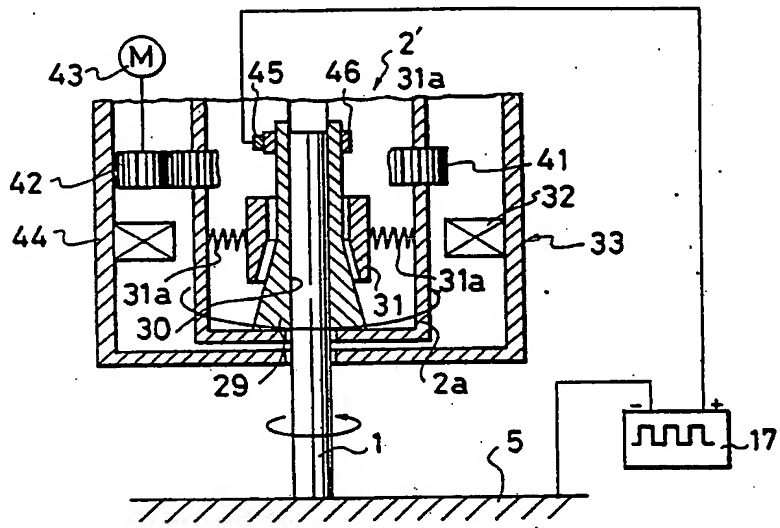

FIG. 6